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Adhesive properties of Araldite AY103

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Abstract

The results of tests to compare the adhesive properties of pure Araldite AY103 and Araldite AY103 with an additive of glass bubbles are described.

For the construction of the OT detector modules it is foreseen to perform the gluings, where the adhesive is in contact with the counting gas, with Araldite AY103 (adhesive) + HY991 (hardener). That choice is based on the excellent out-gassing properties of that adhesive. Another advantage is, that it cures at room temperature. The main requirements for the joints are an excellent gas tightness, good mechanical strength and the ability to produce a joint of well defined thickness.
Joints between the following materials are necessary for the detector modules:

- aluminium – aluminium
- Noryl – aluminium
- G10 – aluminium
- Noryl – G10
- Noryl – Kapton

- carbon fibre – Kapton
- carbon fibre – Rohacell

Dependent of the type of the joint it is desired to control the viscosity of the adhesive during processing. Pure AY103+HY991 has low viscosity. To increase the viscosity the usage of a different type of hardener (e.g. HY956) might be envisaged. Unfortunately due to a lack of out-gassing and ageing tests this is not recommended. Another viable solution is to add low density glass bubbles to the adhesive. Various tests have been performed to investigate whether the mechanical properties of the joints are deteriorated by the usage of glass bubbles.

Preparation of the adhesive

The preparation of the adhesive is done in a standarized procedure. Adhesive and hardener are mixed in a small beaker, obeying the mixing ratio given by the producer (100 parts per weight of AY103 to 40 parts per weight of HY991). The beaker is put under a cover and evaporated. It is mixed for 5–10 minutes by means of a convential blender. Mixing under vacuum is mandatory to avoid air bubbles in the adhesive. Afterwards glass bubbles are added and mixed 2–3 minutes by hand. The glass bubbles are delivered by R & G GmbH Faserverbundwerkstoffe, Germany. Their density is $0.12 g/cm^3$. The quantity added is up to 50 percent of volume of glass bubbles. If not quoted otherwise the volume ratio of glass bubbles to adhesive is 1:1. Figure 1 shows a photograph of the device used for the preparation of the adhesive.

Test of mechanical strength

To compare the mechanical strength of joints made by AY103 with and without an admixture of glass bubbles, pieces of different materials are joined by the adhesives. After approximately 40 hours of hardening the joints are broken and their mechanical strength is judged. We only give qualitative results, since quantitative measurements are rather complex. They should consider for example the preparation and roughness of the surface, the precise thickness of the adhesive layer and its meniscus. No differences in the mechanical strength of joints made by adhesive with and without bubbles are observed. Despite that, the adhesive without bubbles is more brittle. The results of these tests are summarised in table 1. The mechanical strength of joints that are broken within the adhesive layer is determined by the strength of the adhesive itself. For those joints broken between the adhesive layer and the material the contact between material and adhesive is weaker than the adhesive.

Figure 1: Mixing station for the preparation of the adhesive.

Figure 2: Boxes used for the gas tightness tests.

Material	**dimensions**	**adhesive**		**remark**
		AY103 + HY991 no bubbles	AY103 + HY991 with bubbles	
aluminium aluminium	1x20x100 1x20x100	very good	very good	joint broken within adhesive layer
aluminium GFK	1x20x100 1.7x55x35	very good	very good	joint broken within adhesive layer
aluminium GFK	1x20x100 2x55x35	very good	very good	joint broken within adhesive layer
GFK GFK	1.7x55x35 1.7x55x35	very good	very good	joint broken within adhesive layer
aluminium GFK	10x10x30 2x55x35	excellent	excellent	joint broken within adhesive layer
aluminium GFK	10x10x30 1.7x55x35	excellent	excellent	joint broken within adhesive layer
aluminium foil aluminium	thickness 50μm 10x10x30	very good	very good	joint broken between foil and adhesive
aluminium foil roughened aluminium foil roughened	thickness 50μm thickness 50μm	very good	very good	No bubbles: Joint broken between foil and adhesive With bubbles: Joint broken within adhesive layer
aluminium foil not roughened aluminium foil not roughened	thickness 50μm thickness 50μm	good	good	No bubbles: Joint broken within adhesive layer With bubbles: Joint broken between foil and adhesive
CFK + aluminium foil (side wall) aluminium foil roughened	thickness 0.5mm thickness 50μm	very good	very good	No bubbles: Joint broken between side wall and adhesive With bubbles: Joint broken within adhesive layer

Table 1: Test results on mechanical strengths of adhesive joint. Legend: *'Excellent'* Joint can not be broken by hand. *'Very good'* Joint can hardly broken by hand. *'Good'* Joint can be broken by hand, but still sufficient for the application in module construction.

adhesive	**dimension** [mm]	**leak rate** $[s^{-1}]$	**Permeability** $\left[\frac{m}{bar \cdot s}\right]$	**max. pressure** [bar]
AY103 + HY991 no bubbles	800x100x50	$<2\ 10^{-7}$	$<5\ 10^{-7}$	1 ± 0.2
AY103 + HY991 with bubbles	1000x100x50	$<2\ 10^{-7}$	$<5\ 10^{-7}$	1 ± 0.2

Table 2: Results on gas tightness tests of aluminium boxes shown in figure 2.

Gas tightness tests

To test the gas tightness of adhesive joints two boxes are built, made of an U-profile and plexi-glass walls. One box is glued by Araldite AY103 + HY991 without glass bubbles. For the second the same adhesive with glass bubbles was used. Figure 2 shows a photograph of the device used for the preparation of the adhesive. After curing their gas tightness is measured according to the procedure described in [1]. No leak rate within the precision of the measurement was observed for both boxes. From this result a maximum permeability of $5 \cdot 10^{-7} \frac{m}{bar \cdot s}$ is derived. This should be compared with a permeability better than $5 \cdot 10^{-5} \frac{m}{bar \cdot s}$ envisaged for the detector module boxes. All results are summarised in table 2. Finally a destructive test was performed to determine the maximum pressure the adhesive joint stands. The destructive pressure for both boxes was 1 bar.

Conclusion

Despite the fact that using glass bubbles makes the adhesive itself more brittle, the mechanical strengths of the joints behave the same. Also, no differences with respect of gas tightness are observed.

References

[1] 'Specifications for the drift gas quality of the outer tracking system', S.Bachmann, LHCb note 2002-031